5-1940

Some Difficulties Encountered by Students with Secondary Mathematics

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May, 1940

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A Thesis in Mathematics Submitted in Partial Fulfillment of the Requirements

for the

Degree of Bachelor of Science

in the

Division of Arts and Sciences

of

Prairie View State Normal and Industrial College

Prairie View, Texas

May, 1940

Approved 5-13-'40

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***** DEDICATION *****

This thesis is graciously dedicated to my Mother, Mrs. Ida Rigmaiden, and my Father, Henry Rigmaiden for their encouragement, loyal sacrifice and devotion.

***** ACKNOWLEDGMENT *****

The Writer is indebted to Prof. A. W. Randall, Head of the Mathematics Department, Prairie View College, Prairie View, Texas, to Dr. R. Patterson Perry, Assistant Director of the Division of Arts and Sciences, and Head of the Natural Science Department, Prairie View College, Prairie View, Texas, and to Mrs. L. Naomi Raibon, Assistant Professor of Mathematics, Prairie View College, Prairie View, Texas for their helpful suggestions and assistance in assembling and compiling this thesis.

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INTRODUCTION

Mathematics is a subject in which all schools require that you must enroll. Students who take up the study of mathematics find the work extremely difficult and distasteful. Such students frequently complain that they were good in Mathematics while in High School or that they have never studied Mathematics or that they have forgotten the mathematics necessary for their success in the course. This is not altogether surprising. It seems that the teachers in our secondary schools are too lenient, thus, over rating the student. The student then goes to college with little or no knowledge of mathematics.

Purpose of the Study

The purpose of the present study is:

(1) To determine the computational difficulties of students with secondary mathematics.

(2) To indicate those difficulties which need more attention.

(3) To measure the abilities of the students with certain Mathematical skills.

(4) To determine causes of these difficulties and suggest measures for remedial purposes.

Scope of Survey

The first move in carrying out the purpose of this investigation was the preparation of a computation test requiring the solution of problems of which students should have been familiar with in High School.

The test was then administered to seventy-eight Freshmen College students who had completed a semester's work in Mathematics; sixty-eight males and ten females.

Chapter I

Computational Difficulties

Preliminary Findings:

Of the seventy-eight students who took the test their ages ranged from fifteen to twenty-nine, with an average age of nineteen. Seventy-eight thought that Mathematics was useful. Eleven did not like Mathematics while sixty-seven did. Sixty-eight stated that they studied mathematics while in High School; six said that they did not study, and four gave no answer. Nine stated that they had an average of "B"; twenty-six had an average of "C"; nine had an average of "D" and four gave no answer; Two students admitted that they were overrated; seven underated; seventy-three said they liked their teacher; fifty-five were of the average and fourteen gave no answer; two stated that they liked their teacher fairly well and one said no, while two gave no answer. Of the teachers who taught these students, fifty-three were males, fourteen females and eleven students had both male and female teachers while going through their High School career. Seventy-three students believed that their teacher knew mathematics; two fairly well; one stated no and two gave no answer. Seventy-two believed their teachers to be good teachers; two fair, three did not and one gave no answer. Fifty students did not believe their teachers partial while seventeen did and eleven gave no answer.

Construction of the Computation Test:

The extent to which students possess or lack necessary skill in Mathematics can be determined accurately only by means of an actual test. With this in mind a test was prepared of which many items were taken unchanged from the texts used in secondary schools. Other items have been simplified somewhat in order to reduce the amount of skill necessary.

In arranging the order of exercises within the test, those items that appeared easy were placed at the beginning, and those that looked difficult were placed near the end. An effort was made also to start off each of the separate groups with an easy exercise.

Computation Test

I. Simple Mathematics

Perform the indicated operations:

Addition:

1.	2.	3.	4.
4386 2459 307 4596 8947	4.32 53.2 .238	2 1/8 3 3/4 4 1/4	6 1/8 4 3/6 5

Subtraction:

1.	2.	3.	4.
3008 1725	48.94 30.79	802,070.00 128,973.45	5 1/2 1 3/4

Multiplication:

.84 9.6	5.5 0	40 .01	4 1/2 6	4/6 x 3/4 =	50^0 =	$50^1 = 25^2$ =

Division:

$.8 \overline{)49.92} =$ $\quad 5/4 \div 4/8 =$ $\quad .009 \overline{)\ 18} =$

Percentage:

30% of 50 = $\quad$ 33 1/3% of 63 = $\quad 12\frac{1}{2}\%$ of .56 = $\quad$ 100% of 7.1=

Change to percent:

Example: $\frac{1}{2} = 50\%$

1/3 = $\quad$ 1/6 = $\quad$ 1/7 = $\quad$ 2/3 = $\quad$ 5/8 = $\quad$ 1/12 =

Change to fractions:

Example: $50\% = \frac{1}{2}$

25% = $\quad$ 20% = $\quad 12\frac{1}{2}\%$ = $\quad$ 66 2/3% =

II. Algebra

Find the value of:

$(\pm 5) \pm (\pm 3) =$
$(\pm 6) - (\pm 3) =$
$(-7) - (-2) =$
$(\pm 8) - (-4) =$
$(-6) \pm (-4) =$
$(-10) \pm (-4) =$
$(\pm 7) \times (\pm 3) =$
$(\pm 6) \times (-2) =$
$(-5) \times (-4) =$

$(\pm 12) \div (\pm 2) =$
$(-9) \div (-3) =$
$(-10) \div (\pm 2) =$
$y^6 \div y^2 =$
$y^5 \times y^4 =$
$y^{2/3} \times y^{1/6} =$
$(6x \pm 8y) \div 2 =$
$(-5)^3 =$
$\sqrt{9x^4} =$

$\sqrt[3]{8x^9} =$
$\sqrt{2} \times \sqrt{8} =$
$(49a^2)^{\frac{1}{2}} =$
$(27a^6)^{1/3} =$
$\left(\frac{-8}{b^3}\right)^{1/3} \cdot \sqrt[3]{\frac{x^3a}{27}} =$
$\frac{x^2 - a^2}{(x \pm a)^2} \times \frac{2x \pm 2a}{3x} =$

Solve for unknown:

$6a - 2(a \pm 1) = 0$
$8(2 - s) = 9(1 - 2s) - 3$
$2x^2 - 4x \pm 16 = 0$

Solve the following systems of equations:

$2x \pm 6 = 7$
$3x - y = 3$

$a - 2b \pm c = 5$
$2a \pm b - c = -1$
$3a \pm 3b - 2c = -4$

$x^2 \pm y^2 = 85$
$x - 1 = 1$

Express with positive exponents: Example: $8^{-4} = \frac{1}{8^4}$

$\frac{1}{10^{-3}} =$ $\quad 10^{-7} =$ $\quad \frac{1}{a^{-2}} =$ $\quad a^{-4}b^5 =$

Express with fractional exponents:

$2\sqrt[5]{x^2}$ $2\sqrt{x}$

Write the Quadratic formula.

Expand by Binomial Theorem:

$(a + x)^4$

In $2x^3y^4$, 2 is the ____; 3 is the ____of x; and 4 is the _____ of y.

III. Geometry

1. There are _____degrees in a triangle.
2. Three types of triangles are _____, _____, and _____.
3. The complement of 30° is _____.
4. The supplement of 30° is _____.
5. There are _____ minutes in a degree.
6. One base angle of an isosceles triangle is 30°, the size of the other two angles are _____ and _____.
7. Any point equidistant from the sides of an angle lies on the _____of the angle.
8. _____perpendicular(s) can be drawn to a line at a (number) point in the line.
9. There are _____ sides to a Quadrilateral.
10. There are _____ degrees in a Quadrilateral.
11. There are_____ degrees in a circle.
12. A straight line perpendicular to a radius at its outer extremity is _____ to the circle.
13. The tangents to a circle from an outside point are (equal, unequal).
14. Parallel lines intercept _____ on a circle.
15. There are _____ degrees in a rectangle.
16. Check the following lines which meet in a point:

    a. Altitude of a triangle.
    b. Perpendicular bisectors of the sides of a triangle.
    c. Bisectors of a triangle.
    d. Medians of a triangle.

The purpose for which the various exercises were included in the test may be indicated in a very few words. The test was divided into three parts: Simple Mathematics or Arithmetic, Algebra and Geometry. The first four problems were intended to test the student's ability in addition of whole numbers, decimals and mixed numbers. The next group of problems were included to test the student's ability in subtraction of whole numbers, decimals and mixed numbers. The next eight problems included Multiplication of decimals, fractions, mixed numbers, and also raising numbers to a certain power. The next three problems were there to test the students in division of decimals and fractions and their ability to locate decimal points. Following, a group of problems were included to test the student's ability in percentage, again involving the placement of decimal points. The next two groups were included solely to test the student's ability in changing fractions to percent and percent to fractions.

Part two of the test was included as Algebra. The first group of problems, twenty-four in number, were included to test the student's ability in addition, subtraction, multiplication and division of numbers with like and unlike signs, extraction of roots, multiplication and division of letters raised to powers and multiplication of radicals and fractions. The second group was equations, composed of two simple equations and one quadratic equation to be solved for the unknown. The quadratic

equation had no real roots. The next group was composed of systems of equations to be solved simultaneously. This group was composed of two simple equations, then a group of three equations, and then a simple equation and a second degree equation. Following,a group was included to test the students ability in expressing numbers with negative exponents to numbers with positive exponents. The next group was composed of radicals to be expressed as fractional exponents. Then a little memory was required to write the Quadratic formula and to expand a binomial to the fourth power by the Binomial Theorem. The last problem in Algebra was included to have the names or terms of certain numbers given.

The Third part of the test was composed of Geometry. Many of the important fundamentals were selected to see how much the students had learned and retained. The more simple ones were selected.

Administering and Scoring the Test:

The test was completed in the summer of 1939 but was not given to the Freshmen students at Prairie View until after they had completed a semester's work there. The test was given to only seventy-eight Freshmen students. No particular student was selected to take this test. It was just given to those who obtained papers before they gave out.

Sixty minutes were allowed to take the test. All the returned papers were scored by one person, the writer.

The scoring procedure was simple. Each correct answer was counted as one point. There was a total of 100 points. Omitted problems were marked as errors.

Computational Errors:

The frequency with which correct, incorrect, and omitted answers were noted for each exercise is shown in Table I (A, B, and C). An inspection of the figures in the second column of this table will give a general idea of the relative difficulty of the various exercises. Those exercises that students considered difficult may be detected by noting the number of ommissions in column four. A few exercises that looked easy actually were missed with high frequency.

The causes of many of the mistakes which were made may be inferred from the answers given. In order to facilitate the study of these erroneous answers, a tabulation was made of those mistakes that occurred more often. These mistakes have been designed typical errors. A summary of typical errors is presented in Table I. There were in some cases, however, errors which could not be termed typical. In many cases the Writer was not able to determind how a student could derive some such answers as were given . The typical errors themselves can best be appreciated by examining them in the settings in which they were noted. For this reason these errors will be discussed in detail.

In the very first problem under addition the typi-

cal error resulted because of simple carelessness in placing a decimal point for a comma. Many of the answers differed, however. The next three problems had no typical errors.

Under subtraction there were three typical errors. In the first case, instead of the student writing 1283 he wrote 2283. He forgot that one unit had been borrowed from the last digit. The second case resulted because the student did not know what to do with the figures to the right of the decimal points. In the third case, the typical error resulted from the fact that the fractions were subtracted separately from the numbers regardless of position.

In the Multiplication there were four typical errors. In the first error it was a result of failure to place in the decimal point. The next error resulted because the student did not know that zero multiplied by a number is zero. The next error resulted because the student did not know how to point off. For .40 they wrote .040. The fourth typical error resulted because the student did not know that a number raised to the zero power is one. Many students also gave the answer of zero as well as fifty-one.

In Division there were two typical errors, or it might be said three, because one problem had two typical errors. All resulted because of the student's lack of knowledge regarding decimals.

The two typical errors in Percentage resulted because the student did not know where to place the decimal point.

In the next group the two typical errors resulted because the student was careless. They wrote 14 1/7 for 14 2/7 and gave the result for 1/8 instead of 5/8^{ths}.

The next group or last group under General Mathematics had no typical errors.

Out of the seventy-eight students who took the test only one said that $51^{0} = 1$.

Part two of the test, composed of Algebra, had very few typical errors. Most of the problems were omitted. In the first group there were fifteen typical errors in twenty-four problems. That was all the typical errors in this second part or Algebra. The omitted column was very large in figures. Most of the typical errors resulted because the students were unable to handle signs. In many cases it was just a matter of sign for the problem to be correct.

In multiplying and dividing numbers with exponents the students multiplied and divided the exponent. One outstanding error resulted from $(49a^{2})^{\frac{1}{2}}$. The student took $\frac{1}{2}$ of 49 and the square root of a. This was done in a number of cases.

It was found that the students could not work simple equations. Most of them were omitted. Table I will show the result of those that were worked. There were

three problems under Algebra in which no student could work. There were four problems in Algebra in which only one student could work; two problems that two students could work; two problems that three students could work; and two problems that four students could work. This shows that the students were not so good in Algebra.

Part three, composed of Geometry, had a number of typical errors. Many of these errors resulted because the students were never well informed. They said that there were 360° in a triangle. They named three types of triangles as right, acute, and obtuse. Now that was not the students fault, for he has been informed that those are the three types of triangles. We may successfully say that a right triangle is a kind of triangle, but in the writers estimation, he believes that a teacher should never inform a student that acute and obtuse are kinds of triangles. True enough they are names for angles but should be carried no further. For example: suppose the angles of a triangle are 30°, 100°, and 50°; we have two acute angles and one obtuse angle. Some authors would call that an obtuse triangle according to angles.

They stated that 15° was the supplement of 30°. Undoubtedly they thought that the sum of supplementary angles was 45°. In a number of cases the students did not know what an isosceles triangle was. Being given 30° as one base angle they said that the other two angles were

60 and 90 degrees. In other instances, however, the answer was 75 and 75 degrees. They said that a rectangle had 180 ; and that a quadrilateral had 180 . Most of the remaining problems had typical errors becuase of bad memory.

TABLE I A

Number of correct; incorrect and omitted answers to the exercises; correct answers and typical errors

Exercise	No. of Answers correct	incorrect	omitted	Correct Answers	Typical errors
I. General Math.					
A. Addition					
1.	56	22	0	20,695	20.695
2.	74	4	0	57.758	———
3.	74	4	0	10 1/8	———
4.	66	12	0	15 5/8	———
B. Subtraction					
1.	60	18	0	1283	2283
2.	67	11	0	18.15	———
3.	39	39	0	673096.55	67309.45
4.	41	37	0	3 3/4	4¼
C. Multiplication					
1.	48	30	0	8.064	8064
2.	39	34	5	0	5.5
3.	61	16	1	.40	.040
4.	67	11	0	27	—
5.	44	10	24	½	———
6.	1	32	45	1	51/0
7.	24	8	46	50	———
8.	28	16	34	625	———
D. Division					
1.	34	40	4	62.4	6.24
2.	54	14	10	2½	———
3.	23	49	6	2000	2 & .002
E. Percentage					
1.	47	23	8	15	———
2.	31	23	24	21	———
3.	30	28	20	.07	7
4.	33	26	19	7.1	.71
F. Change to Percent					
1.	67	3	8	33 1/3%	———

Table I Cont'd.

Exercise	No. of Answers Correct	Incorrect	Omitted	Correct Answers	Typical Errors
2.	63	7	8	16 2/3%	
3.	46	17	15	14 2/7%	14 1/7%
4.	57	12	9	66 2/3%	
5.	40	22	16	62 ½%	12 ½%
6.	42	22	14	8 1/3%	
G. Change to Fractions					
1.	71	3	4	¼	
2.	65	5	8	1/5	
3.	56	16	5	1/8	
4.	62	9	7	2/3	
		Table I	B		
II. Algebra					
A.					
1.	60	7	11	8	
2.	51	17	10	3	-9
3.	43	24	11	-5	±9
4.	17	48	13	12	4
5.	34	32	12	-10	10
6.	35	30	13	-14	14
7.	54	11	13	21	
8.	49	17	12	20	-20
9.	43	23	12	-12	12
10.	56	4	18	6	
11.	37	23	18	3	-3
12.	46	13	19	-5	
13.	9	48	21	y^4	y^3
14.	17	37	32	y^9	y^{20}
15.	9	37	32	$y^{\frac{1}{2}}$	y 1/9
16.	17	33	18	$3x \pm 4y$	24 x y
17.	14	16	48	-125	125
18.	10	16	52	$3x^2$	
19.	11	16	51	$2x^3$	
20.	15	15	48	4	
21.	3	21	54	7a	24.5a
22.	2	17	59	$3a^2$	$9a^2$
23.	1	7	70	$\frac{-2x^2}{3b}$	
24.	0	12	66.	$\frac{2(x-a)}{3x}$	
B.					
1.	8	18	52	½	
2.	6	15	57	$\sqrt{-1}$	
3.	1	11	66	$1 \pm \sqrt{7}\ i$	

Table I B Cont'd.

Exercise	No. of Answers Correct	Incorrect	Omitted	Correct Answers	Typical Errors
C.					
1.	2	19	56	$x = \frac{1}{2}$;	
2.	0	5	73	$y = -3/2$	
				$a = 1$;	
				$b = -1$;	
				$c = 2$	
3.	1	6	71	$x = \pm 2$;	
				$y = \pm 9$	
D.					
1.	15	15	48	10^{3}	
2.	29	3	46	$\frac{1}{10^{2}}$	
3.	16	13	49	a^{2}	
4.	4	20	54	b^{5}	
				a^{4}	
E.					
1.	3	5	70	2x 2/5	
2.	4	5	69	2x 1/2	
F.					
1.	1	0	77	——	
G.					
1.	0	1	77	——	
H.					
a.	13	10	55	coeficient	
b.	24	1	53	exponent	
c.	24	1	53	exponent	

Table I C

IV. Geometry					
1.	52	14	12	180	360
2.	69	87	78	scalene	right
				equilateral	acute
				isosceles	obtuse
3.	20	4	54	60	
4.	18	6	54	150	15
5.	53	47	46	30	60 | 75
				120	90 | 75

Table I C Cont'd.

Exercise	No. of Answers			Correct Answer	Typical Error
	Correct	Incorrect	Omitted		
6.	34	7	37	60	
7.	6	16	56	bisector	center
8.	20	9	49	one	2
9.	54	4	20	four	
10.	29	10	39	360	180
11.	44	7	27	360	
12.	26	8	44	tangent	perpendicular
13.	19	11	48	equal	unequal
14.	4	20	54	equal arcs	no where
15.	24	12	42	360	180
16. a.	28	50	0	check	
b.	30	48	0	check	
c.	33	45	0	check	
d.	24	54	0	check	

Summary of Sources of Computational and Manipulative Difficulties

Looking over the mistakes of the test as a whole, it is possible to summarize briefly the sources of these difficulties.

It was found that carelessness in computation played a large role. Certain digits were omitted from the answers. Failure to place the right sign before an answer occurred quite often. It was quite obvious that the student did not check his work. Since everyone is capable of making a mistake, it is absolutely essential that all work be checked. Students should therefore be taught effective and economical methods of checking their computations.

Although the operations with negative numbers give rise to many errors, the principles governing negatives are so simple that anyone capable of doing satisfactory work in Mathematics should be able to relearn these principles with no other help than that of an elementary Algebra text.

The ability to handle fractions is one phase of the work that the student should really study. Of course they will need the teacher's help to relearn, if they ever knew, how to handle fractions.

The skill of placing the decimal point was lacked

in many cases, and it need be revived. In the problem .009)18 , only twenty-three students of the seventy-eight were able to place the decimal point. Some had the answer 2 while others had .002.

Glancing over the results of the test, the writer concluded that much work is not covered in Mathematics in our secondary schools. Many problems were omitted. Those problems which were omitted occur most frequently the fartherest over in the average text book used. Only one person attempted to write the quadratic formula, and only one person attempted to expand a given bionomial by the bionomial theorem. In many other cases, as denoted in Table No. I, problems were omitted.

Students after completing secondary mathematics should have retained the most common things in geometry. In many cases these faults do not lie in the student entirely, but also in the teacher. Although our teaching system is improving, it has not yet reached its best. It is yet a long ways off. It should be noticed that most of the students who took this test said that their marks in High School were A and B, and their marks on the test certainly did not indicate it.

Results of the Test as a Whole:

The success and failures of the students who took the test have been discussed. Table II gives us the information as to how well these students succeeded with

the test as a whole. The marks are rather poor. No one made a perfect score. The highest mark was 82 and the lowest 14, as is shown in Table II. The average score for the test was 37.3 while the average score per person on the individual parts was as follows:

Arithmetic 66.2, Algebra 11.3, Geometry 34.5

From these results one can clearly see that the students were not so efficient in Algebra. The mark for Arithmetic was entirely too low for students who have completed secondary Mathematics.

Mathematical Training and Success on the Test:

The seventy-eight students who took this examination had completed secondary mathematics and a semester's work in College Mathematics. Of the seventy-eight students, nine said that they had an average of A while in high school mathematics; thirty-eight had an average of B; twenty-six had an average of C; one had an average of D; and four gave no answer. According to these averages and the results of the test either one of two things can be concluded:

1. That the student placed down the wrong average.

2. That the entire fault lies with the teacher.

Many students leave high school and as shown by the results of the test cannot handle decimals and common fractions. Some cannot handle percentage.

TABLE II

Number Making Score	Score
1	82
1	78
1	77
1	66
1	65
1	63
3	59
1	58
1	56
2	55
2	52
2	50
1	49
2	48
2	46
3	45
1	44
2	42
4	40
3	39
2	38
1	36
2	35
1	34
3	33
5	31
1	30
2	29
1	28
3	27
4	26
1	25
2	24
4	21
2	20
1	19
2	18
2	15
4	14
Average	37.3

Chapter II

Other Mathematical Difficulties

The students who work secondary mathematics encounter many difficulties of a mathematical nature that are quite independent of his computational shortcomings. He may or may not possess a fair mastery of the computational skills and still have trouble in understanding problems. The number and persistence of any student's difficulties are affected by the character and the amount of subject matter introduced and the method used in its preparation.

Difficulties of Thinking in a Symbolic Language:

One difficulty is that of thinking in a symbolic language. This seems extremely difficult for some persons. Such relations as $I = p\ r\ t$ and $A = \pi r^2$, as well as others that are frequently used are statements of general relationships. These relationships are not readily grasped by the student. These relations should be used to accustom the student not only to the use of letters, in the place of numbers and to the solution of simple numerical problems, but also to the idea, for example that changes in "r" affect the value of A. Such questions as the following should be considered: If "r" is doubled, what will happen to I? Appreciation of the meaning of such relationships will tend to clarify the entire subject under consideration.

Without such an appreciation, it may be doubted whether

the student had any real grasp of the matter.

Difficulties In Interpreting Graphs:

The principles underlying graphic representation are in most cases understood without any trouble. But the difficulty lies in the fact that students are confused when the scales along the two axes are not in the same units. Students are further confused by the fact that changing the size of the units along the axes may modify the appearance of a graph without affecting the numerical relationship of its parts. In particular they find it hard to reconcile the varying forms of the normal curve.

During the second semester of the school year 1938 - '39 at Prairie View State College, the Writer taught a course in Mathematics called Analytic Geometry. He actually discovered that three-fourth of the class could not plot a simple graph correctly. He did not, however, attribute this fact to that of difficulty so much as that of background. The students interest in graphing had never been motivated to the extent that he understood the principles of graphing.

Failure to Understand Proofs:

In most secondary Mathematics' text, examples of problems and proofs of statements are given. The student reads these examples and proofs with little

or no thought being given to what he reads. Thus it occurs that he does not have a clear concept of what his work is all about. It is true that students go on into the act of attempting to work problems with what he considers to be a fair knowledge of the proofs in the example, which is in reality no knowledge at all. In many cases students do not stop to read proofs in the examples but dive into the actual working of problems and the conquences are that they do not get the assignment prepared.

Difficulties In the Interpretation of Worded Problems:

One of the most important modes of thought is the ability to grasp a situation, to seize the facts, and to preceive correctly the state of affairs.

This is pre-requisite to success in any undertaking, but it is a hard thing to do. The real facts must often be sifted with care. It is a fact (and most teachers will agree with the writer) that students in secondary mathematics are able to work abstract problems much easier than concrete ones. Concrete problems are stated in the form of sentences, and the students are not able to seize the facts. Much practice is required to even fair success in grasping situations, and that practice is not usually given in secondary schools.

What has preceded evidently demands that the entire course of instruction tends to make the pupil

appreciate clearly and quickly what is given and what is to be found and done. This feature can hardly be made too prominent. Much of the lack of success which some pupils experience is due to weakness at this point. The pupils plunge headlong to do something at all hazards, instead of holding himself in hand and first deliberating on what he is to do and what materials and tools he has with which to do it.

When the situation is grasped, and the facts are well in hand, inferences must be made from them and conclusions must then be drawn. Until this procedure is used successfully by students, they will always have difficulty with worded problems.

Chapter III

Mathematical Ability and Success in Secondary Mathematics

Students are unable, because of inadequate mathe- background, to do satisfactory work in secondary Mathematics.

The pupils' attitudes have much to do with their success in secondary Mathematics. Pupils as well as others think that you have to have a special mind to study Mathematics. Those who are actually working in the field, who have had much experience in teaching Mathematics to all types of pupils, have generally abandoned this opinion, so far at least as primary and secondary Mathematics are concerned. The simple reasoning of school Mathematics can be understood by any normal mind if properly presented.

Some pupils are tempted to evade precisely that portion of the work which gives the benefit, by memorizing the results of the work of the others. This temptation is great to some pupils, and perhaps no other subject can become so barren and dreary as Mathematics thus studied. Ten pages of Mathematics understood are better than a hundred memorized and not understood. The question is not how much? but how?

Chapter IV

Summary and Suggestions

Summary

Opinions of Teachers:

There is a general feeling among teachers of Secondary Mathematics that students will not apply themselves, their mathematical background is poor, thus, many students fail to do satisfactory work in mathematics.

Computational Difficulties:

A test of these fundamental secondary mathematical skills was constructed and administered to the seventy-eight freshmen college students previously mentioned. The items of the test that were most frequently missed were those that called for (1) locating the decimal point in division and less frequently in multiplication, (2) raising a number to the zero power, fractional exponents and a little less frequently to the first and second powers, (3) Multiplication and division of fractions and complex numbers, (4) placement of the correct sign to the sum, difference, product and quotient of like and unlike numbers, (5) Extracting the square root and cube root of whole numbers and fractions, (6) Multiplication and division of letters with exponents, (7) solv-

ing for unknowns, (8) solving systems of equations, (9) Expressing numbers with negative exponents into those of positive exponents, and (10) Expressing numbers under radicals with fractional exponents. Other sources of error were: (11) Writing the Quadratic formula, (12) Expanding by means of the binomial theorem, (13) Identifying the terms of a Mathematical expression, (14) Remembering fundamental principles in geometry, (15) Neglecting to check all numerical operations, and (16) Failing to complete an exercise.

Other Mathematical Difficulties:

Some additional mathematical difficulties that arise in secondary schools are:

(1) Difficulty of thinking in a symbolic language
(2) Difficulty in interpreting graphs
(3) Failure to understand proofs
(4) Difficulty in interpreting worded problems.

Mathematical Ability and Success in Secondary Mathematics:

The attitudes of the pupils have much to do with his success in secondary mathematics. He has the ability to do the work if he is a normal individual and the material is properly presented to him. He, of course, must also apply himself to the actual work and not depend on the work of others.

- Suggestions -

Overcoming Mathematical Difficulties:

Some ways in which the findings of this investi -

gation may be employed to modify the teaching of Secondary Mathematics will be suggested in this section.

From the results of the test, it was concluded that many important topics were never touched in secondary mathematics (especially in Algebra). It is best for a teacher to eliminate some of the less essential topics from the course and teach fewer more important topics more thoroughly. The teacher should outline a course of study for an entire year. The teacher should be able to determine the type of mode* to use and at which time it should be employed.

The teacher should include in her program diagnostic testing in order to determine the students knowledge in Mathematics. Then he should follow up with remedial work. At least three diagnostic tests should be given. In this way the teacher will be able to determine just where the students difficulty occurs. In this way the teacher will be able to determine the students ability to learn and the peculiar manner in which individuals learn best.

* Young, J. W. A. The Teaching of Mathematics in the Elementary and Secondary School pp. 53-68

Aspects of Secondary Mathematics That Need Emphasis:

In the light of the needs of students in Mathematics there are a number of items that seem to deserve additional emphasis in secondary mathematics. A minimum list of such items should include the following:

1. Rational method of locating the decimal point
2. Conventional order of algebraic operations
3. Systematic checking of numerical and algebraic operations
4. Practice in translating from symbols to words and words to symbols
5. Evolution of formulas with attention to Algebraic signs
6. Manipulation of radicals and fractions
7. Equation of a straight line and quadratics
8. Raising numbers to fractions
9. Principles governing positive and negative numbers.
10. Rational method of extracting roots
11. System of equations

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